INDOOR AIR QUALITY ASSESSMENT

Norton High School
66 West Main Street
Norton, Massachusetts

Prepared by:
Massachusetts Department of Public Health
Center for Environmental Health
Emergency Response Indoor Air Quality Program
June 2005

Background/Introduction

At the request of building occupants and parents, the Massachusetts Department of Public Health's (MDPH) Center for Environmental Health (CEH) provided assistance and consultation regarding indoor air quality at the Norton High School (NHS), 66 West Main Street, Norton, Massachusetts. Concerns about mold growth as well as a number of symptoms occupants attributed to poor indoor air quality prompted the request. On March 23, 2005, Cory Holmes and Sharon Lee, Environmental Analysts in CEH's Emergency Response/Indoor Air Quality (ER/IAQ) Program, conducted an assessment. MDPH staff were accompanied for portions of the assessment by Tom Withers, Head Custodian.

The NHS is a two-story, brick and cinder block building constructed in 1971. The second floor contains general classrooms, science classrooms, girl's locker room computer labs and the library. The first floor contains general classrooms, wood shop, auditorium, gymnasium, boy's locker room, kitchen, cafeteria, art room, computer rooms, guidance and health suites and office space. Windows are openable throughout the building.

Methods

Air tests for carbon monoxide, carbon dioxide, temperature and relative humidity were taken with the TSI, Q-Trak, IAQ Monitor, Model 8551. Screening for total volatile organic compounds (TVOCs) was conducted using a Thermo Environmental Instruments Inc., Model 580 Series Photo Ionization Detector (PID). MDPH staff also performed a visual inspection of building materials for water damage and/or microbial growth.

Results

The NHS houses approximately 700 students in grades 9 through 12 and approximately 60 staff members. Tests were taken under normal operating conditions and results appear in Table 1.

Discussion

Ventilation

It can be seen from the Table 1 that carbon dioxide levels were elevated above 800 parts per million parts of air (ppm) in thirty-five of sixty areas surveyed, indicating inadequate air exchange in more than half of the areas examined on the day of the assessment. It is important to note that several areas with carbon dioxide levels below 800 ppm were sparsely populated, unoccupied and/or had windows open; these conditions can greatly reduce carbon dioxide levels. Carbon dioxide levels would be expected to be higher with full occupancy.

Fresh air in exterior classrooms is supplied by unit ventilator (univent) systems (Picture 1). A univent is designed to draw air from outdoors through a fresh air intake located on the exterior wall of the building (Picture 2). Return air is drawn through an air intake located at the base of each unit (Figure 1). Fresh and return air are mixed, filtered, heated and provided to classrooms through a fresh air diffuser located in the top of the unit. Univents appear to be original equipment, approximately 35-40 years old. Efficient function of such aged equipment is difficult to maintain, since compatible replacement parts are often unavailable. The majority of univents were operating during the assessment; however, some univents had been deactivated (Table 1). In order for univents to provide fresh air as designed, these units must remain "on" and allowed to operate while rooms are occupied.

Exhaust ventilation in classrooms is provided by ceiling vents powered by rooftop motors (Pictures 3 and 4). The majority of ceiling vents throughout the building appeared to be drawing weakly or not at all, which can indicate that motors were deactivated or non-functional. MDPH staff observed exhaust motors on the roof and found a number of them deactivated or not operating. In some science classrooms, exhaust vents are not located in classrooms but are located in the ceiling of adjacent storerooms. Exhaust ventilation is provided by drawing classroom air through a passive door vent into the storeroom (Picture 5).

Mechanical ventilation in interior classrooms, and common areas such as the cafeteria, auditorium, library and gym, is provided by rooftop air handling units (AHUs) (Picture 6). Fresh air drawn into outside air intakes and is distributed via ductwork connected to ceiling mounted air diffusers (Picture 7). Exhaust ventilation is provided by ceiling-mounted exhaust grills that are ducted back to AHUs. These AHUs were operating during the assessment.

To maximize air exchange, the MDPH recommends that both supply and exhaust ventilation operate continuously during periods of school occupancy. In order to have proper ventilation with a univent and exhaust system, the systems must be balanced to provide an adequate amount of fresh air to the interior of a room while removing stale air from the room. The date of the last balancing of these systems was not available at the time of the assessment. It is recommended that existing ventilation systems be re-balanced every five years to ensure adequate air systems function (SMACNA, 1994). The mechanical ventilation systems, in their current condition, cannot be balanced.

The Massachusetts Building Code requires that each room have a minimum ventilation rate of 15 cubic feet per minute (cfm) per occupant of fresh outside air or openable windows (SBBRS, 1997; BOCA, 1993). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week, based on a time-weighted average (OSHA, 1997).

The MDPH uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches. For more information on carbon dioxide see Appendix A.

Temperature readings ranged from 69 ^{o} F to 79 ^{o} F, which were very close to the MDPH comfort guidelines. The MDPH recommends that indoor air temperatures be maintained in a range of 70 ^{o} F to 78 ^{o} F in order to provide for the comfort of building occupants. A number of temperature control/comfort complaints were expressed by occupants during the assessment. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply. In addition, it is difficult to control temperature and maintain comfort without operating the ventilation equipment as designed (e.g., univents and/or exhaust vents deactivated/not operating).

The relative humidity ranged from 16 to 30 percent, which was below the MDPH recommended comfort range in all areas the day of the assessment. The MDPH recommends a comfort range of 40 to 60 percent for indoor air relative humidity. Relative humidity levels in the building would be expected to drop during the winter months due to heating. The sensation of dryness and irritation is common in a low relative humidity environment. Low relative humidity is a very common problem during the heating season in the northeast part of the United States.

Microbial/Moisture Concerns

A large number of areas (e.g., classrooms, hallways, offices) had water-stained ceiling tiles, which can indicate leaks from the roof or plumbing system (Picture 8). The building has a history of roof leaks and still experiences periodic leaking. School maintenance personnel reported that attempts are made to make repairs (i.e. patches) as needed to prevent water infiltration. Water-damaged ceiling tiles can provide a source for mold and should be replaced after a water leak is discovered and repaired.

Mortar was missing or crumbling from the exterior walls of the greenhouse (Picture 9). These conditions are breaches of the building envelope and can provide a means for water entry into the building. Several other breaches around the perimeter of the building were seen, such as holes around local exhaust vents (Picture 10) and portions of missing or damaged expansion joint (Picture 11). Repeated water penetration can result in the chronic wetting of building materials and the potential for microbial growth. In addition, large wall cracks/breaches may provide a means of egress for pests/rodents into the building.

The gutter/downspout system was damaged/missing in several areas, and sections of the exterior wall were saturated with moisture (Pictures 12 and 13). Excessive exposure of exterior brickwork to water can result in structural damage. Over time, these conditions can undermine the integrity of the building envelope and provide a means of water entry into the building through capillary action through foundation concrete and masonry (Lstiburek & Brennan, 2001).

Open seams between the sink countertop and wall were observed in several rooms (Table 1). If not watertight, water can penetrate through the seam, causing water damage. Water penetration and chronic exposure of porous and wood-based materials to moisture can cause these materials to swell and show signs of water damage. Moistened materials that are not dried within 24 to 48 hours can become potential sources for mold growth.

The US Environmental Protection Agency (US EPA) and the American Conference of Governmental Industrial Hygienists (ACGIH) recommends that porous materials be dried with fans and heating within 24 to 48 hours of becoming wet (US EPA, 2001; ACGIH, 1989). If porous materials are not dried within this time frame, mold growth may occur. Water-damaged porous materials cannot be adequately cleaned to remove mold growth. The application of a mildewcide to moldy porous materials is not recommended.

Plants were noted in several classrooms. Plants can be a source of pollen and mold, which can be respiratory irritants for some individuals. Plants should be properly maintained and equipped with drip pans. Plants should also be located away from univents to prevent the aerosolization of dirt, pollen or mold.

Other Concerns

Indoor air quality can also be impacted by the presence of materials containing volatile organic compounds (VOCs). VOCs are substances that have the ability to evaporate at room temperature. Frequently, exposure to low levels of total VOCs (TVOCs) may produce eye, nose, throat and/or respiratory irritation in some sensitive individuals. For example, chemicals evaporating from a paint can stored at room temperature would most likely contain VOCs. Slight chemical odors from the acid storage locker were detected in the chemical storeroom in the science wing. In an effort to determine whether measurable levels of VOCs were present, air monitoring for TVOCs was conducted. Outdoor air samples were taken for comparison. Outdoor TVOC concentrations were non-detect (ND) (Table 1). TVOC measurements directly in front of the storage locker ranged from ND to 0.5 ppm.

Please note, TVOC air measurements are only reflective of the indoor air concentrations present at the time of sampling. Indoor air concentrations can be greatly impacted by the use TVOC containing products (e.g., the concentration of TVOCs within a classroom increases when the product is in use).

In addition to being a potential source of VOCs, improperly stored chemicals in the science prep room can pose a fire and safety hazard. The following conditions were noted in the chemical storage area in the science wing:

- Acid bottles appeared leaking with crystallized material on the outside of bottle; some labels also appeared corroded, making identification difficult (Picture 14).
- Doors of the storage locker did not close properly (Picture 15).
- Items were labeled with chemical formula instead of the chemical name (Picture 16).
- Some items were missing labels (Picture 17).

- Unidentified materials appeared to have leaked onto metal shelving, causing corrosion. Leaked material also appears to have dripped onto materials directly below (Pictures 18 and 19).
- Guardrails did not exist on the edge of shelves to prevent containers from accidentally slipping from shelves.

It is highly recommended that a thorough inventory of chemicals in the science department and art rooms be done to assess chemical storage and disposal in an appropriate manner consistent with Massachusetts's hazardous waste laws.

Dry erase markers and cleaners were seen in many classrooms. Materials such as dry erase markers and dry erase board cleaners may contain VOCs, (e.g. methyl isobutyl ketone, n-butyl acetate and butyl-cellusolve) (Sanford, 1999).

In an effort to reduce noise from sliding chairs, tennis balls had been spliced open and placed on chair legs in some areas. Tennis balls are made of a number of materials that are a source of respiratory irritants. Constant wearing of tennis balls can produce fibers and off gas VOCs. Tennis balls are made with a natural rubber latex bladder, which becomes abraded when used as a chair leg pad. Use of tennis balls in this manner may introduce latex dust into the school environment. Some individuals are highly allergic to latex (e.g., spina bifida patients) (SBAA, 2001). It is recommended that the use of materials containing latex be limited in buildings to reduce the likelihood of symptoms in sensitive individuals (NIOSH, 1997). A question and answer sheet concerning latex allergy is attached as Appendix B (NIOSH, 1998).

A number of other conditions that can affect indoor air quality were noted during the assessment. Older model univents appear to be equipped with metal mesh filters that provide minimal filtration of respirable particulates (Picture 21). In order to decrease aerosolized particulates, disposable filters with an increased dust spot efficiency can be installed in these units. The dust spot efficiency is the ability of a filter to remove particulates of a certain diameter from air passing through the filter. Filters that have been determined by ASHRAE to meet its standard for a dust spot efficiency of a minimum of 40 percent would be sufficient to reduce airborne particulates (Thornburg, D., 2000; MEHRC, 1997; ASHRAE, 1992). Note that increased filtration can reduce airflow produced by the unit by increased resistance; this condition is known as pressure drop. Prior to any increase of filtration, each univent should be evaluated by a ventilation engineer to ascertain whether they can maintain function with more efficient filters. The univent in the wood shop is located directly under the wood dust collector (Picture 22). This configuration can result in the draw of aerosolized dust into the univent and subsequent distribution throughout the room. In addition, the accumulation of wood dust in heating components may pose a fire hazard.

Exhaust vents and fan blades to personal fans were occluded with dust. Reactivated fans and univents can serve to distribute accumulated dust. If exhaust vents become deactivated, backdrafting can occur, resulting in the re-aerosolization of accumulated dust particles. Also of note was the amount of materials stored inside classrooms. In several areas, items were observed on windowsills, tabletops, counters, bookcases and desks. The large number of items stored in classrooms provides a source for dusts to accumulate. These items (e.g., papers, folders, boxes) make it difficult for custodial staff to clean. Dust can be irritating to the eyes, nose and respiratory tract. For this reason, items should be relocated and/or cleaned periodically to avoid excessive dust build up. Accumulated chalk dust was noted in some classrooms. Chalk dust is a fine particulate that can easily become aerosolized, irritating eyes and the respiratory system.

Finally, several areas contained window-mounted air conditioners or portable air purifiers. This type of equipment is normally equipped with filters that should be cleaned or changed as per manufacturer's instructions to prevent the build up and re-aerosolization of dirt, dust and particulate matter.

Conclusions/Recommendations

The conditions related to indoor air quality problems at the NHS raise a number of issues. The general building conditions, maintenance, work hygiene practices and the condition of ventilation equipment, if considered individually, present conditions that could degrade indoor air quality. When combined, these conditions can serve to further negatively affect indoor air quality. Some of these conditions can be remedied by actions of building occupants. Other remediation efforts will require alteration to the building structure and equipment. For these reasons a two-phase approach is required. This approach consists of **short-term** measures to improve air quality and **long-term** measures that require planning and resources to adequately address the overall indoor air quality concerns.

The following **short-term** measures should be considered for immediate implementation:

1. Examine each univent for function. Survey classrooms for univent function to ascertain if an adequate air supply exists for each room. Consider consulting a heating, ventilation and air conditioning (HVAC) engineer concerning the calibration of univent fresh air control dampers.

2. Use openable windows in conjunction with classroom univents and exhaust vents to facilitate air exchange. Care should be taken to ensure windows are properly closed at night and weekends to avoid the freezing of pipes and potential flooding.
3. Inspect exhaust motors and belts for proper function. Repair and replace as necessary.
4. Ensure univents and exhaust vents remain free of obstruction to ensure adequate airflow.
5. Operate all ventilation systems that are operable throughout the building (e.g., gym, auditorium, classrooms) continuously during periods of school occupancy independent of thermostat control to maximize air exchange.
6. Consider having ventilation systems re-balanced every five years by an HVAC engineering firm.
7. Consider developing a written notification system for building occupants to report indoor air quality issues/problems. Have these concerns relayed to the maintenance department/ building management in a manner to allow for a timely remediation of the problem.
8. For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, scrupulous cleaning practices should be adopted to minimize common indoor air contaminants whose irritant effects can be enhanced when the relative humidity is low. To control for dusts, a high efficiency particulate arrestance (HEPA) filter equipped vacuum cleaner in conjunction with wet wiping of all surfaces is recommended. Avoid the use of feather dusters. Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations).

9. Continue working with a roofing contractor to identify and make roof repairs as needed to prevent further water penetration.
10. Ensure leaks are repaired, and replace water damaged ceiling tiles. Examine the area above and around these areas for mold growth. Disinfect areas of water leaks with an appropriate antimicrobial.
11. Contact a masonry firm or general contractor to repair holes/breaches in exterior walls to prevent water penetration, drafts and pest entry. Ensure all leaks are repaired. Once leaks are repaired, replace/repair any water-damaged building materials.
12. Repair/replace elbow extensions on downspouts to direct rain water away from the building.
13. Ensure plants have drip pans. Examine drip pans periodically for mold growth and disinfect with an appropriate antimicrobial where necessary. Keep plants away from the air stream of univents.
14. Conduct a chemical inventory in all storage areas and classrooms. Discard hazardous materials or empty containers of hazardous materials in a manner consistent with environmental statutes and regulations. Follow proper procedures for storing and securing hazardous materials. Obtain Material Safety Data Sheets (MSDS') for chemicals from manufacturers or suppliers.
15. Make repairs or take measures to secure the doors to the acid storage cabinet in the chemistry storeroom.
16. Maintain MSDS' and train individuals in the science department in the proper use, storage and protective measures for each material in a manner consistent with the Massachusetts Right-To-Know Law, M.G.L. c. 111F (M.G.L., 1983).

17. Change filters for all air-handling equipment as per the manufacturer's instructions or more frequently if needed. Vacuum interior of units prior to activation to prevent the aerosolization of dirt, dust and particulates. Ensure filters fit flush in their racks with no spaces in between allowing bypass of unfiltered air into the unit. Particular attention should be made to the univent in the wood shop.
18. Consider replacing metal filters in older model univents with disposable filters.
19. Consider increasing the dust-spot efficiency of HVAC filters. Prior to any increase of filtration, each piece of air handling equipment should be evaluated by a ventilation engineer as to whether it can maintain function with more efficient filters.
20. Clean univent return vents and exhaust vents periodically of accumulated dust.
21. Relocate or consider reducing the amount of materials stored in classrooms to allow for more thorough cleaning of classrooms. Clean items regularly with a wet cloth or sponge to prevent excessive dust build-up.
22. Clean accumulated dust from exhaust vents and blades of personal fans.
23. Clean chalkboard/dry erase marker trays and pencil sharpeners regularly to prevent the build-up of excessive chalk dust and particulates.
24. Discontinue the use of tennis balls on chairs to prevent latex dust generation.
25. Consider adopting the US EPA document, "Tools for Schools", to maintain a good indoor air quality environment on the building (US EPA, 2000). This document can be downloaded from the Internet at: http://www.epa.gov/iaq/schools/index.html.
26. Refer to resource manuals and other related indoor air quality documents for further building-wide evaluations and advice on maintaining public buildings. These

materials are located on the MDPH's website at

http://www.state.ma.us/dph/MDPH/iaq/iaqhome.htm.

The following **long-term measures** should be considered:

1. Contact an HVAC engineering firm for a full evaluation of the ventilation systems building-wide. Based the age, physical deterioration and/or availability of parts of the HVAC system, this evaluation is recommended to ensure proper operation and/or necessary repair/replacements.
2. Consider consulting with an architect, masonry firm or general contractor regarding the integrity of the building envelope, primarily concerning water penetration through exterior walls. This measure should include a full building envelope evaluation.
3. Consider relocating wood dust collection unit outside the building. At the very least the unit should be located away from the general proximity of the unit ventilator.
4. Consider total roof replacement including the removal of historical "patches".

References

ACGIH. 1989. Guidelines for the Assessment of Bioaerosols in the Indoor Environment. American Conference of Governmental Industrial Hygienists, Cincinnati, OH.

ASHRAE. 1989. Ventilation for Acceptable Indoor Air Quality. American Society of Heating, Refrigeration and Air Conditioning Engineers. ANSI/ASHRAE 62-1989

ASHRAE. 1992. Gravimetric and Dust-Spot Procedures for Testing Air-Cleaning Devices Used in General Ventilation for Removing Particulate Matter. American Society of Heating, Refrigeration and Air Conditioning Engineers. ANSI/ASHRAE 52.1-1992.

BOCA. 1993. The BOCA National Mechanical Code/1993. 8th ed. Building Officials & Code Administrators International, Inc., Country Club Hills, IL.

Lstiburek, J. & Brennan, T. 2001. Read This Before You Design, Build or Renovate. Building Science Corporation, Westford, MA. U.S. Department of Housing and Urban Development, Region I, Boston, MA

MEHRC. 1997. Indoor Air Quality for HVAC Operators & Contractors Workbook. MidAtlantic Environmental Hygiene Resource Center, Philadelphia, PA.

MGL. 1983. Hazardous Substances Disclosure by Employers. Massachusetts General Laws. M.G.L. c. 111F.

NIOSH. 1997. NIOSH Alert Preventing Allergic Reactions to Natural Rubber latex in the Workplace. National Institute for Occupational Safety and Health, Atlanta, GA.

NIOSH. 1998. Latex Allergy A Prevention. National Institute for Occupational Safety and Health, Atlanta, GA.

OSHA. 1997. Limits for Air Contaminants. Occupational Safety and Health Administration. Code of Federal Regulations. 29 C.F.R 1910.1000 Table Z-1-A.

Sanford. 1999. Material Safety Data Sheet (MSDS No: 198-17). Expo® Dry Erase Markers Bullet, Chisel, and Ultra Fine Tip. Sanford Corporation. Bellwood, IL.

SBAA. 2001. Latex In the Home And Community Updated Spring 2001. Spina Bifida Association of America, Washington, DC.

SBBRS. 1997. Mechanical Ventilation. State Board of Building Regulations and Standards. Code of Massachusetts Regulations. 780 CMR 1209.0.

SMACNA. 1994. HVAC Systems Commissioning Manual. 1st ed. Sheet Metal and Air Conditioning Contractors' National Association, Inc., Chantilly, VA.

Thornburg, D. 2000. Filter Selection: a Standard Solution. *Engineering Systems* 17:6 pp. 74-80.

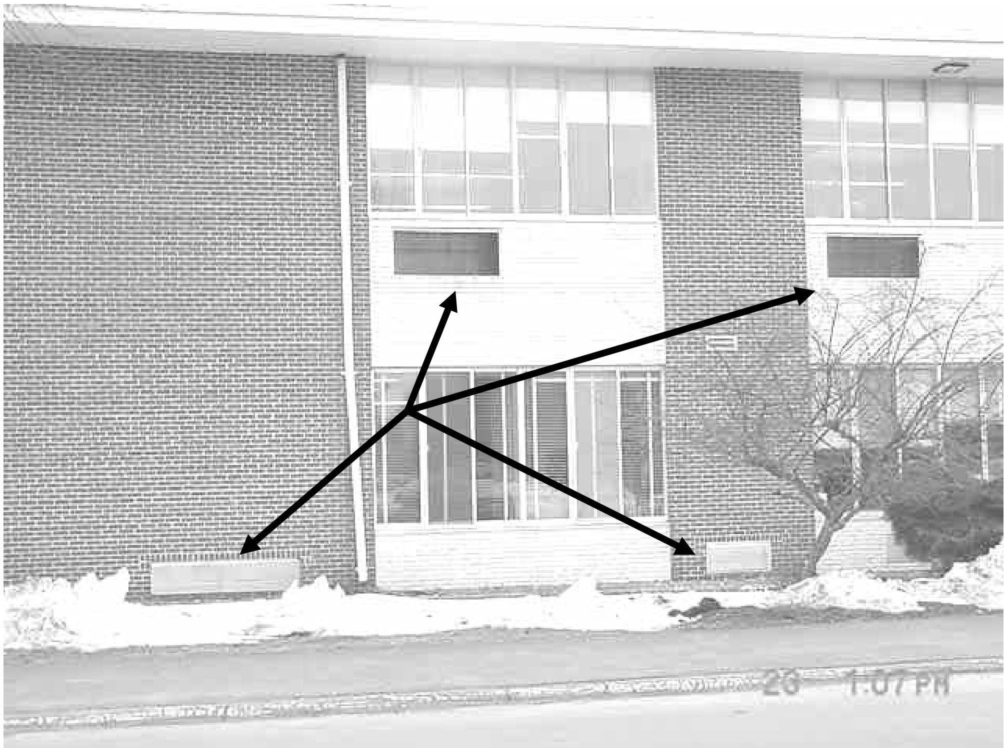
US EPA. 2000. Tools for Schools. Office of Air and Radiation, Office of Radiation and Indoor Air, Indoor Environments Division (6609J). EPA 402-K-95-001, Second Edition. http://www.epa.gov/iaq/schools/tools4s2.html

US EPA. 2001. "Mold Remediation in Schools and Commercial Buildings". Office of Air and Radiation, Indoor Environments Division, Washington, DC. EPA 402-K-01-001. March 2001. Available at: http://www.epa.gov/iaq/molds/mold_remediation.html

Picture 1

Classroom Univent 1970's Vintage

Picture 2



Univent Fresh Air Intakes

Picture 3

Classroom Exhaust Vent

Picture 4

Rooftop Exhaust Motors

Picture 5

Passive Door Vent in Science Classroom

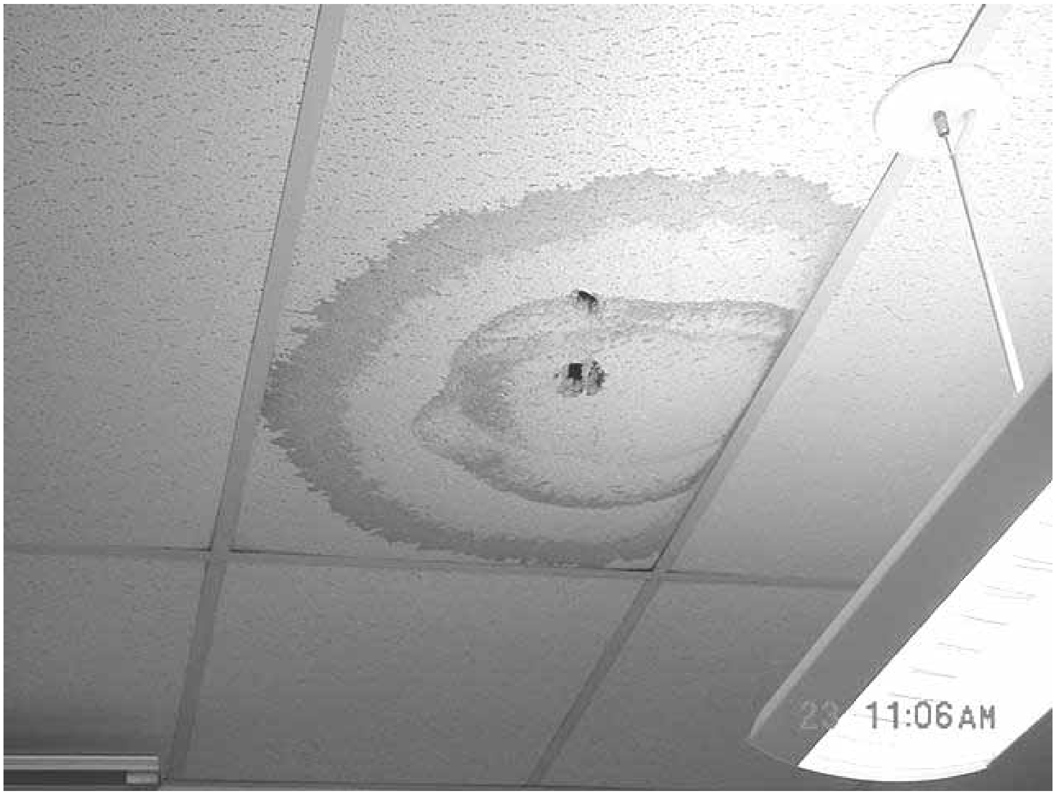
Picture 6

Rooftop Air Handling Units

Picture 7

Ceiling-Mounted Air Diffuser

Picture 8



Water Damaged Ceiling Tile

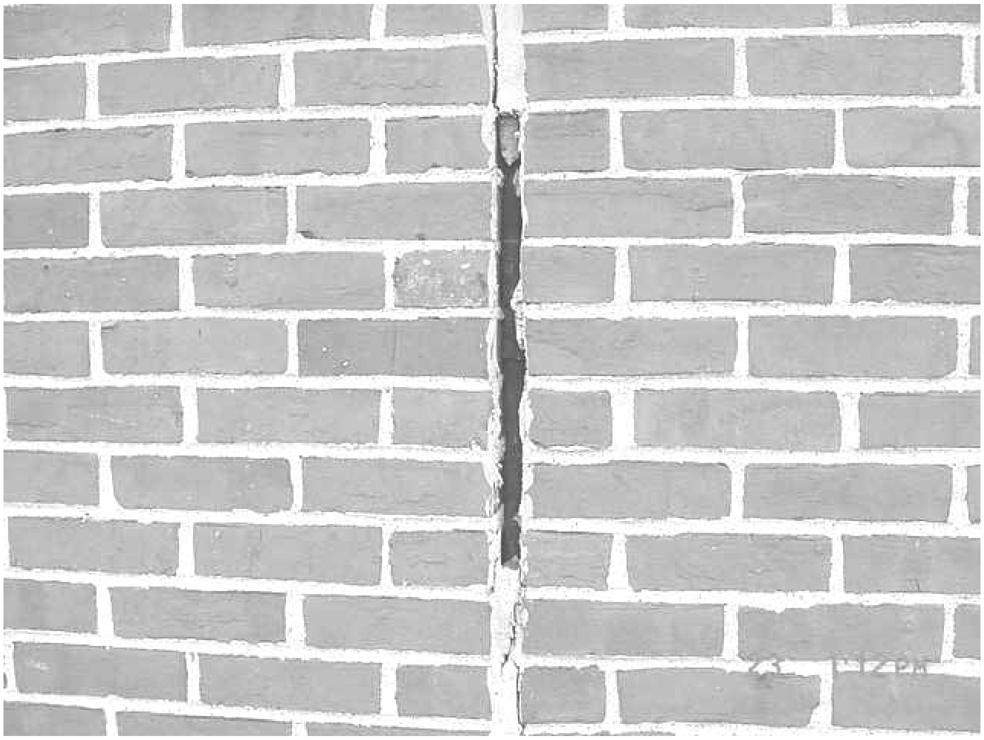
Picture 9

Missing/Damaged Brick/Mortar on Greenhouse

Picture 10

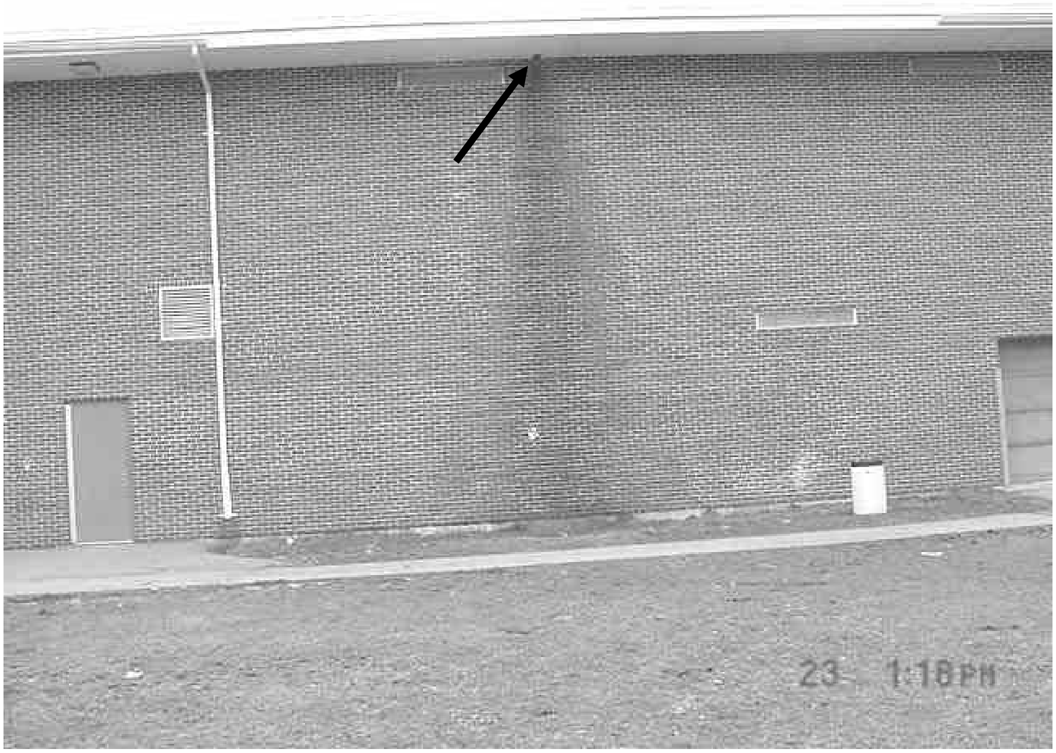
Hole around Local Exhaust Vent on Rear Exterior Wall of NHS

Picture 11



Missing/Damaged Expansion Joint Sealant

Picture 12



Missing Downspout, Note Characteristic Staining Pattern on Brickwork

Picture 13

Missing Elbow Extension, Note Hole below Downspout Where Water Pools against the Foundation

Picture 14

Crystallized bottle of Acid, Note Corrosion on Bottle Making Identification Difficult

Picture 15

Close-up of Acid Storage Locker Doors That do Not Stay Closed

Picture 16

Container Labeled With Chemical Formula

Picture 17

Container with Missing Label

Picture 18

Leaking Material Causing Corrosion of Metal Shelving

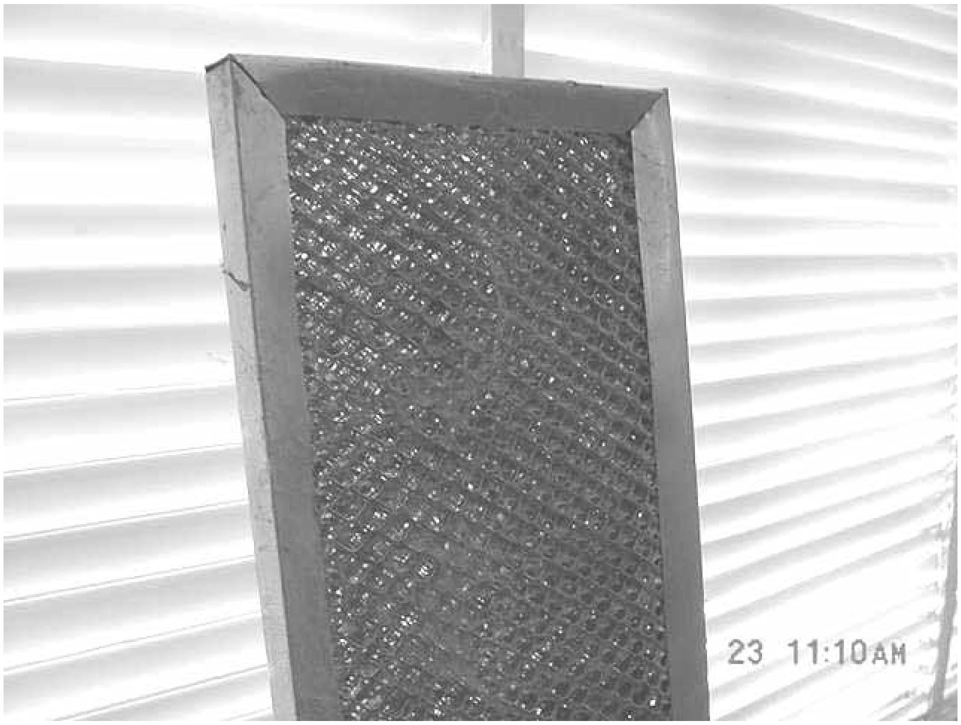
Picture 19

Leaking Material Causing Corrosion of Metal Shelving and Dripping onto Shelving/Materials below

Picture 20

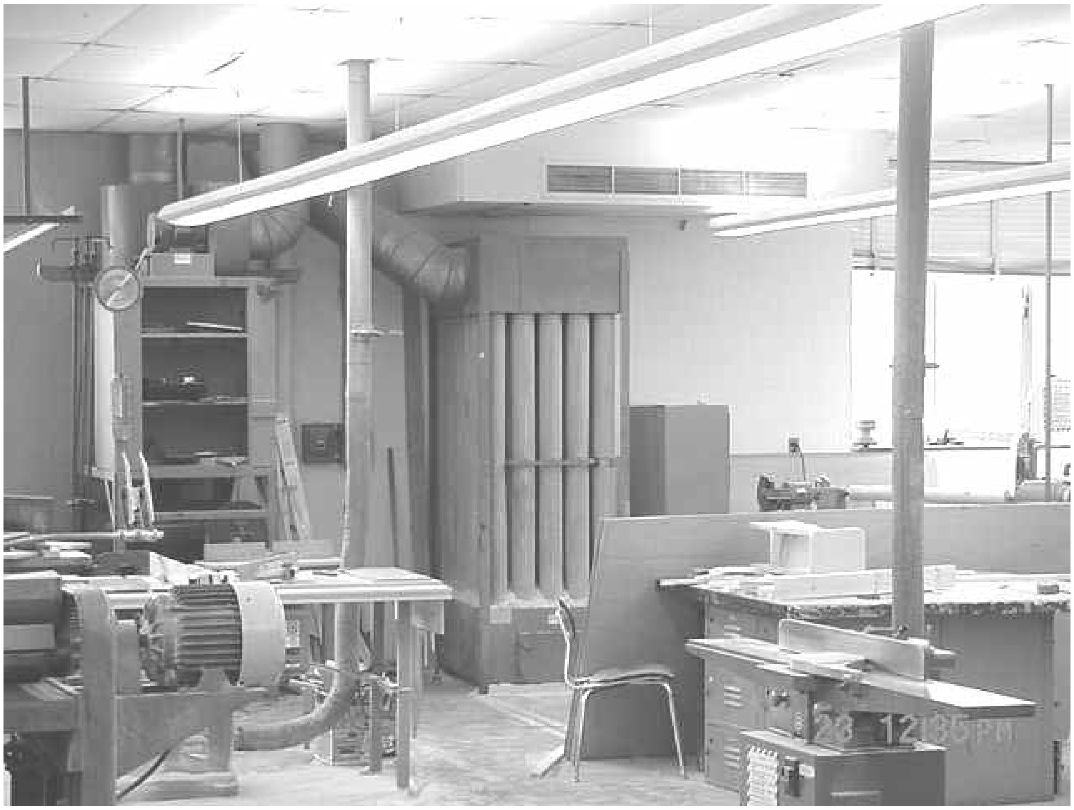
Crucible with Unidentified Crystallized Material on Open Shelf

Picture 21



Metal Mesh Filters in Univents

Picture 22



Wood Dust Collection Unit Directly beneath Ceiling-Mounted Univent

TABLE 1

Indoor Air Test Results – Norton High School — March 23, 2005

Location	Carbon Dioxide (*ppm)	Temp. (°F)	Relative Humidity (%)	Occupants in Room	Windows Openable	Ventilation		Remarks
Outside (Background)	388	50	22					TVOC = ND
Chemical Storeroom					N	Y	Y	TVOC = 0.0-0.5 ppm, slight odors from acid locker
266	530	72	19	0	Y	Y	Y	1 WD CT, exhaust vent in storeroom off/passive supply vent in door
244	1234	76	23	30	N	Y	Y	
247	1055	75	21	3	N	Y	Y	2 WD CT, DO, DEB
246	1177	74	24	26	Y	Y	Y	No draw exhaust vent
245	1300	74	24	28	Y	Y	Y	Bowed CTs, exhaust vent-weak/no draw, UV buzzing noise, DEB
Library	652	73	19	9	N	Y	Y	15 WD CT, DO

ppm = parts per million parts of air
TVOC = total volatile organic compounds
ND = non detectable, DEM = dry erase markers
WD = water damage, CT = ceiling tiles
UV = univent, DO = door open

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 1

Indoor Air Test Results – Norton High School — March 23, 2005

Location	Carbon Dioxide (*ppm)	Temp. (°F)	Relative Humidity (%)	Occupants in Room	Windows Openable	Ventilation		Remarks
Computer Lab 219	740	75	20	1	N	Y	Y	Heat complaints summer/spring-no AC, 5 WD CTs, DO
203	1350	72	21	20	Y	Y	Y	DEB, exhaust weak/no draw
205	2216	79	30	27	Y	Y	N	Heat issues, DEB
Boys Locker Room	616	69	19	10	N	Y	Y	
Wood Shop	560	70	19	5	Y	Y	Y	Wood dust collector directly under UV, DO, window open-pressurized
Art 156	1019	71	23	26	Y	Y	N	Kiln-vented to outside, 3 WD CT
153	950	73	23	7	Y	Y	Y	9 WD CT, exhaust weak/no draw
Music	588	74	20	0	Y	Y	Y	Exhaust no draw, dehumidifier in storeroom, 1 WD CT

ppm = parts per million parts of air
TVOC = total volatile organic compounds
ND = non detectable, DEM = dry erase markers
WD = water damage, CT = ceiling tiles
UV = univent, DO = door open

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 1

Indoor Air Test Results – Norton High School **March 23, 2005**

Location	Carbon Dioxide (*ppm)	Temp. (°F)	Relative Humidity (%)	Occupants in Room	Windows Openable	Ventilation		Remarks
Guidance Main	960	73	23	1	Y	Y	N	2 WD CTC
Mc Laughlin Guidance Office	946	76	23	1	Y	Y	N	DO
Kloman Guidance Office	989	75	21	1	N	Y	Y	DO
Main Office	953	75	22	1	Y	Y	Y	3 WD CT
Auditorium	658	73	19	7	N	Y	Y	
207	579	72	16	1	Y	Y	Y	14 occupants gone ~20 min, window open, 3 WD CT, exhaust weak/no draw
211	780	71	19	0	Y	Y	Y	3 WD CT, exhaust weak/no draw
213	1090	71	23	1	Y	Y	Y	16 occupants gone ~ 1 hour, UV-deactivated, exhaust weak/no draw

ppm = parts per million parts of air
TVOC = total volatile organic compounds
ND = non detectable, DEM = dry erase markers
WD = water damage, CT = ceiling tiles
UV = univent, DO = door open

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 1

Indoor Air Test Results – Norton High School March 23, 2005

Location	Carbon Dioxide (*ppm)	Temp. (°F)	Relative Humidity (%)	Occupants in Room	Windows Openable	Ventilation		Remarks
220	785	73	21	3	N	Y	Y	8 WD CT, DO
257	627	72	18	6	Y	Y	Y	
256	579	72	18	1	Y	Y	Y	18 occupants gone 1 hour, 5 WD CT
Cafeteria	1569	75	27	200 +	N	Y	Y	
Gym	596	76	16	7	N	Y	Y	
Girls Locker Room	712	72	21	2	N	Y	Y	
Athletic Office	681	72	20	1	N	N	Y	Dusty exhaust vent, passive door vent
262	686	74	19	3	Y	Y	N	2 WD CT, DEM, passive exhaust vent door
262 Storage	642	74	19	0	N	Y	Y	Passive door vent, exhaust vent dusty, 1 WD CT, DO

ppm = parts per million parts of air
TVOC = total volatile organic compounds
ND = non detectable, DEM = dry erase markers
WD = water damage, CT = ceiling tiles
UV = univent, DO = door open

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 1

Indoor Air Test Results – Norton High School **March 23, 2005**

Location	Carbon Dioxide (*ppm)	Temp. (°F)	Relative Humidity (%)	Occupants in Room	Windows Openable	Ventilation		Remarks
261	843	72	20	2	Y	Y	N	DEM, DO, passive door vent
Green House	725	74	23	0	Y	N	N	WD cement blocks, WD paper
261 Storage	875	73	21	0	N	Y	Y	Passive door vent, dusty exhaust vent, DO
241	1259	73	23	22	Y	Y	Y	Clutter, DEM
242	1185	75	22	16	Y	Y	Y	Fan, ajar CT, DEM
240	901	73	19	0	N	Y	Y	Tennis balls, DEM
243	1184	75	22	27	0	Y	Y	8 WD CT, ceiling fan, exhaust off
Tech Supervisor	703	74	17	1	N	Y	Y	Passive exhaust vent, HEPA purifier, cleaners
202	1706	72	24	20	Y	Y	Y	DEM, 1 WD CT

ppm = parts per million parts of air
TVOC = total volatile organic compounds
ND = non detectable, DEM = dry erase markers
WD = water damage, CT = ceiling tiles
UV = univent, DO = door open

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 1

Indoor Air Test Results – Norton High School **March 23, 2005**

Location	Carbon Dioxide (*ppm)	Temp. (°F)	Relative Humidity (%)	Occupants in Room	Windows Openable	Ventilation		Remarks
204	2195	73	29	25	Y	Y	Y	Supply off, 1 WD CT, DEM, ajar tile
206	1359	73	23	19	Y	Y	Y	Supply blocked with furniture, 7 WD CT, DEM
208 Math Office	783	73	19	1	0	N	N	Door open (hall/inter room)
Math Computer Room	587	75	16	1	Y	Y	Y	Exhaust off, fan, 2 ACs
210	751	73	18	1	Y	Y	Y	DEM, exhaust off
212	1070	74	21	25	Y	Y	Y	Supply/exhaust off/weak, DEM
214	1347	73	22	20	Y	Y	Y	Supply/exhaust off/weak, DEM, DO, plants, chalk dust
221	1646	73	24	24	Y	Y	Y	Exhaust weak/off, DEM, chalk dust
231	760	74	19	1	N	Y	Y	Ceiling fan, personal fan, DEM, ajar CT, 4 WD CT

ppm = parts per million parts of air
TVOC = total volatile organic compounds
ND = non detectable, DEM = dry erase markers
WD = water damage, CT = ceiling tiles
UV = univent, DO = door open

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 1

Indoor Air Test Results – Norton High School **March 23, 2005**

Location	Carbon Dioxide (*ppm)	Temp. (°F)	Relative Humidity (%)	Occupants in Room	Windows Openable	Ventilation		Remarks
230	1089	73	20	22	Y	Y	Y	DEM, clutter, exhaust weak
136	1132	74	22	0	Y	N	Y	4 WD CT, plants, personal fan, DEM, breach sink countertop/sink
137 Art	1156	72	26	1	Y	Y	Y	Exhaust weak/off, clothes dryer-ducted, 3 WD CT, plants, exhaust dusty
138 Art	1058	74	25	21	Y	Y	Y	Exhaust off/weak, pottery items near univent
174	743	72	18	12	Y	Y	Y	Exhaust weak, DEM
175	1303	75	23	19	Y	Y	Y	Exhaust off/weak, DEM, ajar CTs
176	1313	74	23	29	Y	Y	Y	Exhaust off/weak, chalk dust, DEM, breach sink/countertop

ppm = parts per million parts of air
TVOC = total volatile organic compounds
ND = non detectable, DEM = dry erase markers
WD = water damage, CT = ceiling tiles
UV = univent, DO = door open

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 1

Indoor Air Test Results – Norton High School **March 23, 2005**

Location	Carbon Dioxide (*ppm)	Temp. (°F)	Relative Humidity (%)	Occupants in Room	Windows Openable	Ventilation		Remarks
177	1552	74	24	22	Y	Y	Y	Exhaust off/weak, ajar CT, chalk dust, DEM, breach sink/countertop
Business Office	1078	74	22	1	N	Y	Y	
Business Office (Inner)	705	75	19	0	Y	Y	Y	WD plaster, riso copier
Nurse's Office	878	70	25	3	Y	N	Y	Exhaust vent in restroom

ppm = parts per million parts of air
TVOC = total volatile organic compounds
ND = non detectable, DEM = dry erase markers
WD = water damage, CT = ceiling tiles
UV = univent, DO = door open

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%